

In-bore Detonation of Non-standard Ammunition,
Testing a Russian T-55 Tank

Steven J. Reeves and Ralph Scutti

INCIDENT:

On 21 May 2009 the U.S. Army Aberdeen Test Center (ATC) was performing an accuracy and fire control test on a Russian T-55 tank at the H-Field Firing Range, Aberdeen Proving Ground (APG). The three man crew, commander (also loading), gunner and driver were firing Russian designed 100-mm UBK-4M cartridge with the BK5M High Explosive Anti Tank (HEAT) warhead. Upon firing the second round of the day, a catastrophic incident occurred. The warhead exploded in the tank cannon rupturing the tube, killing the commander, fatally injuring the gunner and seriously injuring the driver.

The U.S. Army Combat Readiness/Safety Center (CRC) team arrived on 23 May and initiated their investigation. The authors need to acknowledge the efforts of the CRC team in their thorough and professional investigation. Much of the factual information presented herein was obtained through the combined efforts of the CRC team and individuals in the unit. This paper provides general details surrounding the incident and address contributing factors. The conclusions and recommendations presented herein are those of the authors and not the findings, conclusions or recommendations of the Central Accident Investigation Board.

Throughout the paper unless specifically designated otherwise the term ‘unit’ refers to that team within ATC that was responsible for executing the test and reporting the results. The unit is comprised of engineers and technicians with personnel ranging from less than 1 to 20 plus years of experience in the test, operation and maintenance of Russian designed equipment. The authors of this paper are members of the unit.

DETAILS:

1) In January 2009 testing was initiated on the T-55 tank at the H-Field Firing Range. At this time fourteen armor piercing, fin stabilized, discarding sabot – tracer (APFSDS-T) rounds were fired. The firing of forty-four HEAT rounds was scheduled but field gun not tank ammunition was delivered to the test site. The ammunition delivered was for use in an anti-tank field gun, which was incompatible with the tank. The field gun ammunition was turned in; no HEAT rounds were fired at this time.

In May 2009 the tank HEAT rounds were acquired for testing. Twenty-two of the UBK-4M/BK5M HEAT rounds and 24 APFSDS-T rounds were fired between 14 and 20 May 2009 by the crew as a part of the test. The test scenarios were, stationary tank – stationary target and stationary tank – moving target.

On 21 May 2009 the crew prepared the tank for firing, moving tank – stationary target scenario. The incident occurred on the second round of the day at approximately 0930.

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2) The prevailing conditions were; sunny, air temperature 64°F, and wind 4 mph. The area of the range being used was a level, gravel two lane range road, the target was located 1000 meters down range.

3) The tank commander (test officer and loader) had twenty six years of experience testing tanks with the majority of that experience in foreign designed and manufactured systems. The gunner had six years experience testing military equipment with four years experience in foreign designed and manufactured systems. The driver had eleven years experience testing military equipment with the majority of that experience in foreign designed and manufactured systems.

The crew was not wearing fire retardant personnel protective equipment (PPE) at the time of the incident. ATC standing operating procedures (SOPs) did not clearly identify the PPE requirement for tank main gun firing.

4) The tank was manufactured around 1974. All maintenance logs prior to 1995 were unavailable to the unit. The 100mm gun tube underwent a magnetic particle, bore scope and star gauge inspection in November 2008. The tube was deemed serviceable though the omission of equipment logs prior to 1995 made it impossible to determine a precise round count on the gun system.

The fractured 100-mm cannon (figure 1) was sent to US Army Research, Development and Engineering Command, Armament Research, Development and Engineering Center, Benet Laboratories for a failure analysis.



Figure 1 Failed 100-mm gun tube after incident, 65” and 60” long cracks in images A and B respectively

The final report titled; Evaluation of Failed 100-mm T55 Soviet Tank Cannon, August 2009 concluded ‘Through Benet Laboratories failure analysis and interior ballistics simulations the gun tube could safely fire the BK5M HEAT round. The accident was caused by the BK5M HEAT round detonating in the tube. A reason for the premature detonation is unknown and part of an ongoing investigation. The projectile was at or near maximum acceleration when the event took place.’ The report also stated in the summary; ‘Failure mode of the tube is fast fracture due to an overpressure situation, Projectile travelled approximately 16 inches prior to the event, Tube material had adequate strength to support firing of the HEAT round under normal conditions, The chamber pressure at the time of the accident was 3000 Bars, The residues examined from the bore surface were determined to be rust, brass and elements found in the primer, and The projectile was fired and began to move’.

5) The ammunition fired during this test was Russian designed 100-mm HEAT rounds manufactured in 1971. Fifty six rounds were received at APG in June 1999. Twenty rounds from this lot were fired, remotely from the same T-55 tank (stationary) in 2000 without incident. The remaining 36 rounds were kept in storage bunkers on APG; the rounds did receive a visual quality assurance inspection in May 2006 with “no defects noted; good visual condition”.

Two of the BK5M warheads were examined in October 2008 to determine if the high explosive could be removed. Removal of the projectile’s high explosive main charge was determined to not be feasible due to the design of the projectile and equipment limitations. The HEAT round uses a ‘spit-back’ explosive detonating train to initiate the high explosive main charge. When armed, the GPV-2 fuse at the tip of the round (fig 2) is crushed upon impact with the target. This causes the pezio-generator (fig 3) to generate an electrical pulse sufficient to initiate the electric detonator (fig 3), initiating the fuse explosive train. The fuse detonator (fig 3) fires down the center of the copper cone (fig 2) and ignites the K-1-T base detonator (fig 2) in the body of the projectile. The K-1-T detonator is integral to the high explosive, preventing safe removal of the high explosive main charge.

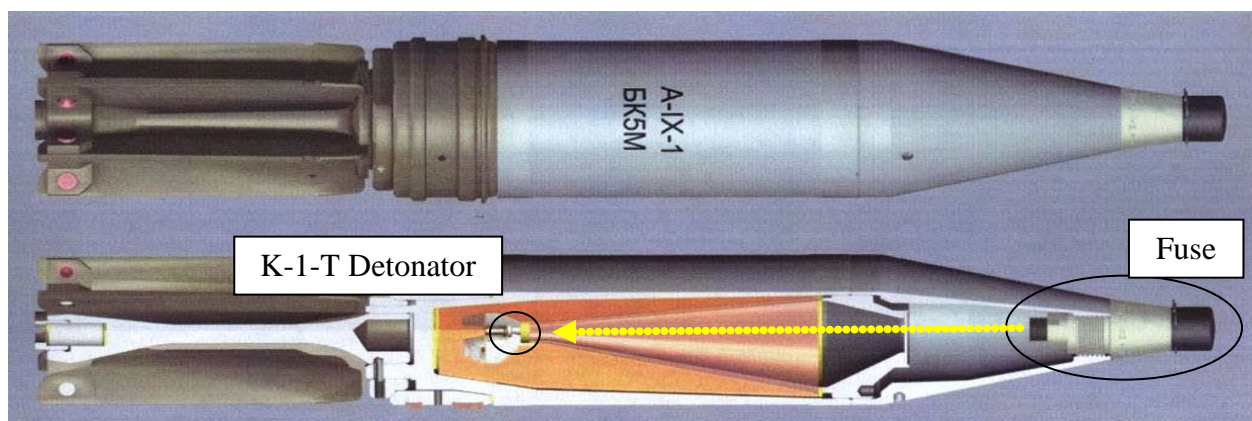


Figure 2 Projectile, Russian BK5M 100-mm HEAT

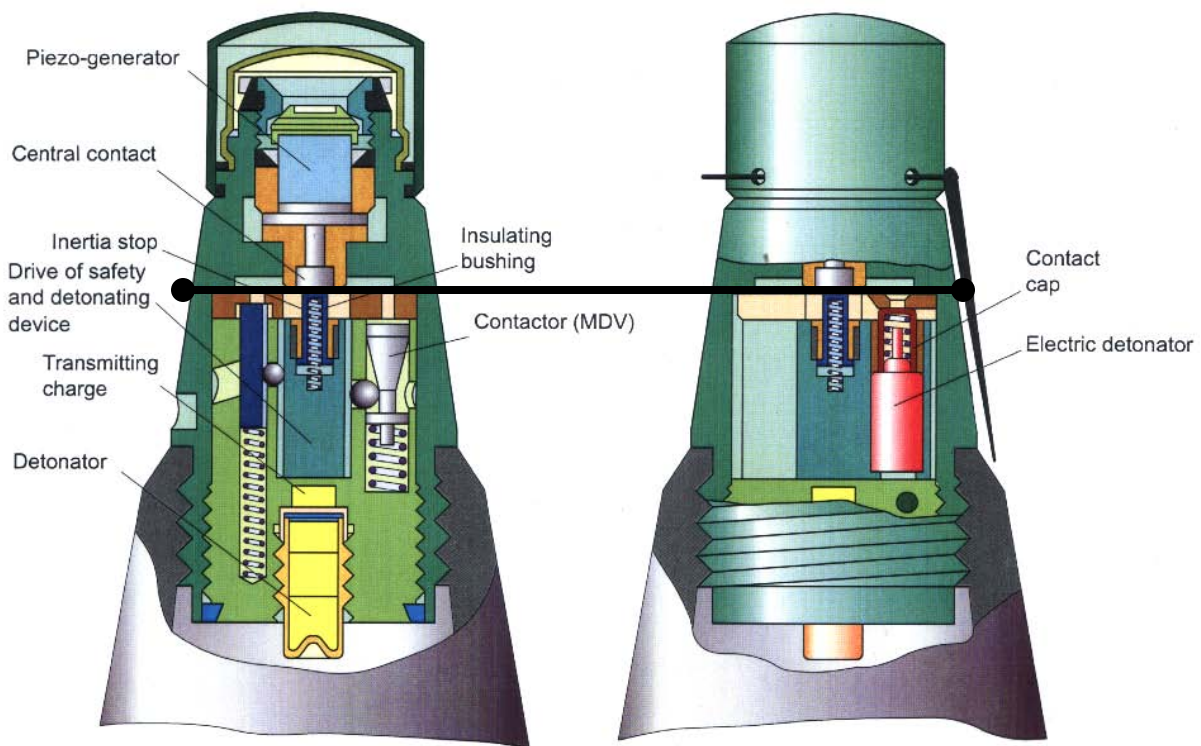


Figure 3 Fuse, GPV-2 for the Russian BK-5M 100-mm HEAT projectile (shown as received).
Modification, all internal components below black line were removed

Since the high explosive could not be removed to totally inert the round the GPV-2 fuse was modified in an attempt to make the projectile less likely to detonate prematurely. The safe and arming mechanism was removed from the GPV-2 fuse, leaving only the pezio-generator and central contact in the fuse. All energetic materials were removed from the GPV-2 fuse. All of the components under the black line (fig 3), the safe and arming mechanism, were removed. The group that performed the modification had documentation indicating that all fuses were modified and all material removed from the fuses was destroyed.

There was no evidence to support the fact that the ammunition underwent an x-ray inspection immediately prior to these firings. The remaining twelve rounds from this lot were marked with 0° and 90° reference points, which is indicative of being x-rayed. It is believed that these rounds were x-rayed prior to the test in 2000. The rounds were then stored in bunkers at APG.

The GPV-2 fuses used in testing were originally supplied with the field gun rounds delivered for testing in January 2009. The fuses had been modified at that time. The modified fuses were removed from the field gun rounds and installed on the tank rounds in May 2009. The field gun round and tank round use the same GPV-2 fuse.

6) All required ATC risk assessment documentation could not be found during the investigation. At the time of the incident ATC required the staffing of an ATC Form 1045R Test Director's Safety Checklist. This form was not staffed for the firing of the T-55 tank. The test director (commander) did have an ATC Form 1045R on the firing range but this addressed the firing of a different tank system (not the T-55). Documentation was found indicating that the risk assessment process was initiated for the T-55 firings but not completed prior to the start of field testing.

The test officer did submit an ATC Form 1045R that included the T-55 firing and the firing of another tank for approval. The authors believe the T-55 firing exercise was removed during the approval process because it did not adequately address the T-55 gun tube inspection process. The other tank firing program was successfully completed a month after the risk assessment was approved. The T-55 firing test was initiated six months after approval of the initial risk assessment. The T-55 risk assessment was never completed.

7) Immediately after the incident occurred range support personnel radioed ATC Range Control requesting emergency medical services (EMS) additionally a 911 call was placed from the H-Field Firing Range Data Collection Facility. The tank continued to move forward and came to rest 400 meters further down range in an unexploded ordinance area. The driver dismounted the tank approximately four minutes after the explosion. Range support personnel trailed the tank and mounted when it stalled approximately eight minutes after the explosion. At this time the commander and gunner were removed from the smoldering tank, basic aid was rendered by range support personnel. EMS arrived at the range approximately 15 minutes after the explosion and two MEDEVAC helicopters landed at the range 50 minutes after the explosion to transport the survivors (driver and gunner) to medical facilities.

The commander was pronounced dead at the scene, the gunner passed fifteen days later from injuries sustained. The driver survived and continues to recover after sustaining third degree burns to approximately 70% of the body.

CONCLUSIONS:

1) The information collected to date indicates to the authors that the incident was caused by an in-bore detonation of a HEAT projectile. The exact cause of the explosion is not known at this time.

2) The authors did not find any factual evidence that indicated any environmental factors contributed to the incident.

3) The authors did not find any factual evidence that indicated the crew performed any actions that caused the incident.

4) The tank crew was not wearing fire retardant clothing. While the tank crew was wearing personnel protective equipment (safety shoes, ear protection, & Russian soft helmet) they were not wearing fire retardant clothing (coveralls, gloves, hood) instead the crew was dressed in jeans and t-shirt. Fire retardant clothing may have lessened the severity of the surviving crew member's injuries.

5) The failure analysis performed by Benet Laboratory concluded that the projectile moved approximately 16 inches down the tube before detonating. Additionally Benet concluded that the gun tube did not fail due to fatigue or wear but rather due to an event (force) that it was not designed to contain.

6) Had the unit consulted Army experts on ammunition, the unit may have determined that the inerting process used would not be a satisfactory risk mitigation. Since the exact cause of the premature detonation is not known, a conclusive statement cannot be made.

7) An ATC Form 1045R Test Director's Check List for the T-55 firings was not found. ATC risk mitigation processes were not followed. Documentation was found indicating that the test officer did initiate the risk assessment process for the T-55 firings but it was not completed. The risk assessment documentation on site at the time of the incident did not specifically address the T-55 firing test but rather the firing of a different tank system. The authors believe the organizational procedures in place failed to ensure that a risk assessment for the T-55 firings was completed. The incident would not necessarily been avoided if a risk assessment had been completed but the incomplete risk assessment did preclude the process from having the chance to identify and mitigate the hazard.

8) In this case medical response was initiated by a 911 call with response from APG Emergency Medical Services (EMS) personnel and from the state police MEDEVAC Unit. Had the injuries been related to blood loss or loss of limb the timeliness of this response may not have been adequate. The EMS personnel that responded service the entire Edgewood Area of APG and were not dedicated to support the firing ranges. ATC is not resourced to have an emergency medical response team available to support any test program let alone a firing program. A request to have EMS personnel on stand-by at the range could be made but given the volume of firing and other hazardous testing the authors believe EMS personnel would spend the majority of their time at the test center in a standby mode. ATC had no medic capability assigned specifically to support test programs. The response time probably seemed like an eternity to the injured and their coworkers on site but EMS personnel were on site and in action within 15 minutes of the incident.

RECOMMENDATIONS:

1) It is recommended that a basic visual and x-ray examination of the remaining twelve UBK-4M 100-mm HEAT cartridges with BK5M projectile and GPV-2 fuses be performed. The examination should be focused on obvious indications as to the cause of the premature detonation. The exterior of the round, fuse well, and GPV-2 fuse should be visually examined for 'abnormalities'. Additionally the cartridges (fuse, high explosive, propellant, etc.) should be

x-rayed to further investigate the cause of the incident. The Army subject matter expert organization (ARDEC) should lead this effort.

This action is currently underway. The procedures to perform the inspections are under review by Army subject matter experts.

2) The circumstances surrounding this incident should be given widest dissemination to educate all users of foreign and non-standard ammunition of the hazards present during this incident.

ATC has completed a set of internal briefings communicating the facts and circumstances surrounding this accident to the workforce. ATC has also briefed the U.S. Army Test and Evaluation Command (ATEC), US Army Developmental Test Command (DTC), sister test centers and ARL as to the events of this incident. Additionally the incident was briefed to the Range Commanders Council Conference at Aberdeen proving Ground in May 2010.

3) Manned firings of foreign weapon systems should be suspended unless adequate safety testing and analysis have been performed to confirm safety of use. Review of the adequacy of a 'test item' for manned firing should be on a case specific basis. The authors recommend that prior to further manned firings of non-standard or foreign manufactured ammunition a working group of experts be convened to assess hazards and to determine the minimal set of data that are required to ensure a reasonable level of confidence that manned firing can be safely executed. This working group of experts should be comprised of experts in the fields of ammunition, weapons and materials. Specific organizations within the U.S. Army are the U.S. Army Research, Development and Engineering Command (ARDEC), Program Manager – Maneuver Armament Systems (PM – MAS) and U.S. Army Research Laboratory (ARL). Involvement should not be limited to these organizations as the process must start from a diverse knowledge base to ensure a robust process and maximize the understanding of the hazards.

ATC has suspended all manned firing of non-standard or foreign ammunition pending identification of the cause of this incident and pending a complete risk assessment of the firing procedures to be used. Informal communications in the test and evaluation community have been initiated to identify the appropriate organizations to participate in a 'manned firing' working group. The formal process is currently being coordinated.

4) The ATC Command has issued a policy letter stating:

'When performing firing or loading operations of the main gun in a combat vehicle, all crew members will wear ATC approved static dissipating, fire resistant clothing, gloves, and balaclava.'

This policy supersedes all standing operating procedures and policies existing on 21 May 2009. ATC has outfitted all personnel involved in such activities with approved clothing. Applicable SOPs have been updated to include a definitive requirement for flame retardant clothing.

5) It is recommended that ATC review the risk assessment process to determine if additional procedures are required to ensure that a test not be initiated before a risk assessment is completed for each particular test.

6) ATC has conducted First Responder training for approximately sixty employees located throughout the test center.

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Testing a Russian T-55 Tank

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July 2010

DISCLAIMER

The information presented herein was obtained through the combined efforts of the Combat Readiness Center (CRC) team and the individuals of the ATC Technical Team, referred to as the Unit. The conclusions and recommendations presented herein are those of the authors and not the findings, conclusions or recommendations of the Central Accident Investigation Board.



Background



- **LOCATION:** H-Field, Edgewood Area of Aberdeen Proving Ground (APG)
- **DATE/TIME:** Thursday, 21 May 2009/ 0925hr
- **EQUIPMENT:** T-55 Soviet Tank, MFD~1974, 100mm UBK-4M HEAT (High Explosive Anti-Tank), with BK5M Warhead, Rounds MFD~1971
- **MISSION:** Conduct Accuracy and Fire Control System Testing of T-55. Testing included both firing and non-firing assessments of the fire control system
- **RESULTS:** 2 fatalities, 1 injured, 1 T-55 tank destroyed
- **ECOD:** Total equipment, \$777,000.00

Personnel Background

- Tank Commander (test officer)
 - Mechanical Engineer, 26 years experience
- Tank Gunner
 - Engineering Technician, 6 years experience
- Tank Driver
 - Engineering Technician, 20 years experience

T-55 Tank



*Army Proven
Battle Ready*

US Army Aberdeen Test Center



Pre-Accident History



DATE:

EVENT:

| | |
|---------------|---|
| 1995 | T-55 arrived in the United States |
| Jul 99 | 56 x 100mm high explosive anti-tank (HEAT) ammunition were received by ATC |
| Aug 99 | 56 x 100mm high explosive anti tank (HEAT) X-rayed |
| Aug 99 | Gun tube inspected (bore scope, star gauge, pull over and magnetic particle), deemed serviceable |
| Aug 99 | 20 x 100mm high explosive anti tank (HEAT) ammunition were remotely fired from T-55 |



Pre-Accident History

DATE:

EVENT:

Feb 00

**36 x 100mm high explosive anti tank (HEAT)
ammunition were turned in to ASP**

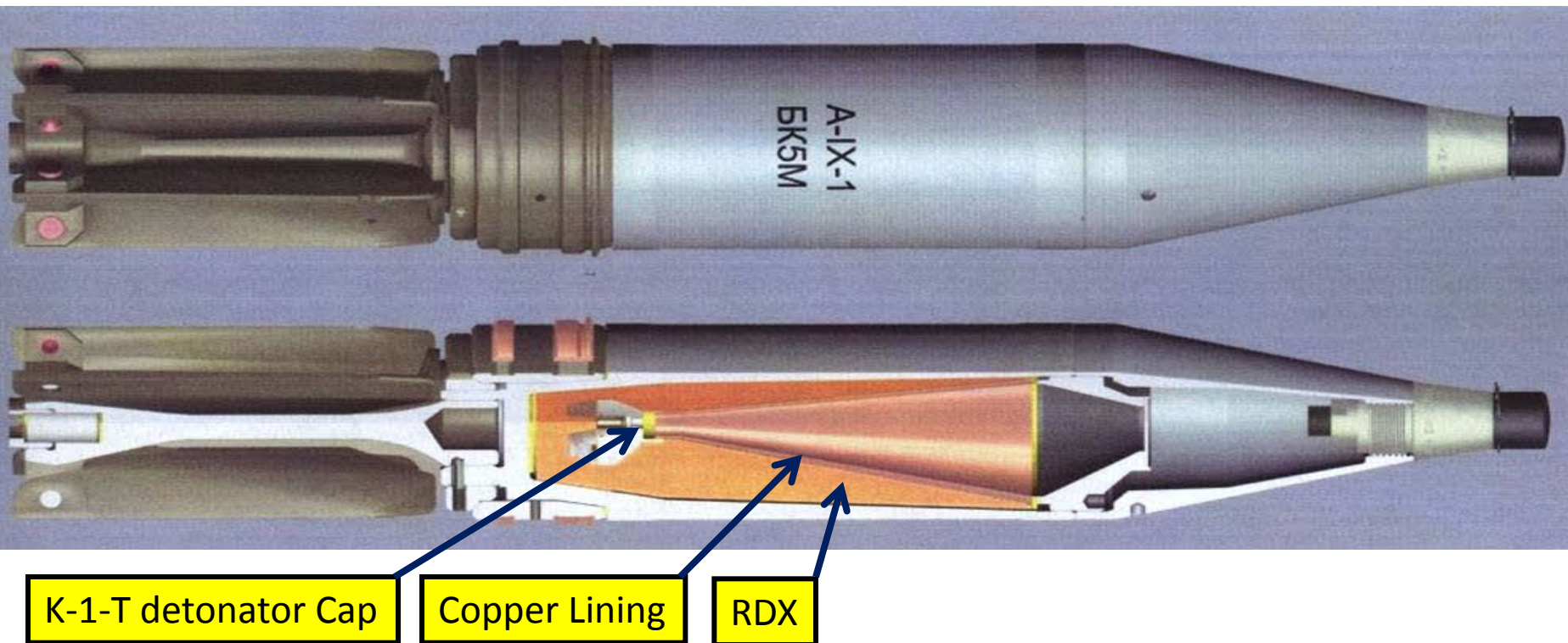
Feb 04

**Evaluation of US systems vs T-55 weapon system
conducted at Yuma Proving Grounds**

Oct 08

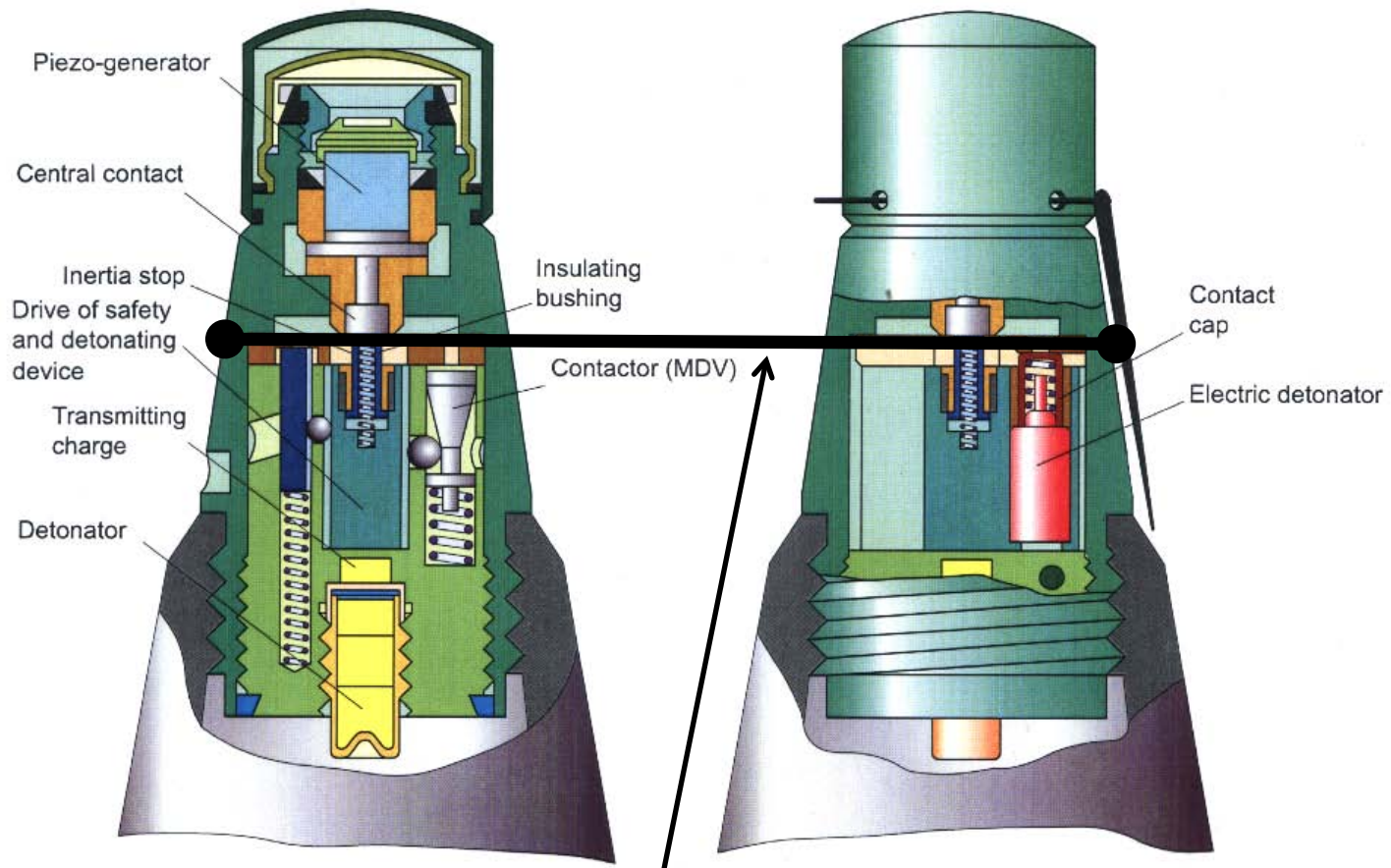
**ATC Ammo technicians inspected two 100mm
rounds (artillery) to determine the method to render
inert the BK5M warhead**

100mm HEAT BK5M Warhead



638mm/25.11" Long, 12.2kg/26.90 lbs

GPV-2 Fuze



Modification Line



Pre-Accident History

DATE:

EVENT:

Oct 08

ATC X-rayed 44 x 100mm HE rounds (artillery)

Nov 08

Tube bore scoped, found worn but serviceable IAW MIL-STD-1949A and MIL-STD-1907

Dec 08

Test officer submitted work order to render inert 44 x GPV-2 fuzes

Jan 09

44 x GPV-2 fuzes modified

Jan 09

44 x GPV-2 energetic materiel destroyed

Jan 09

44 x 100mm HE (artillery) ammunition delivered to H Field; HE testing postponed, 14 AP rounds fired



Pre-Accident History

DATE:

TIME:

EVENT:

07 May 09

36 x 100mm HEAT (tank) ammunition issued

13 May 09

Inerted GPV-2 fuzes swapped from artillery ammunition to the tank ammunition

14 May 09

Remote fired three HEAT rounds on H-Field

15 May 09

1320-1342

Manned firing of seven AP rounds on H-Field

18 May 09

0936-1538

Manned firing of 17 AP rounds on H-Field

20 May 09

0940-1450

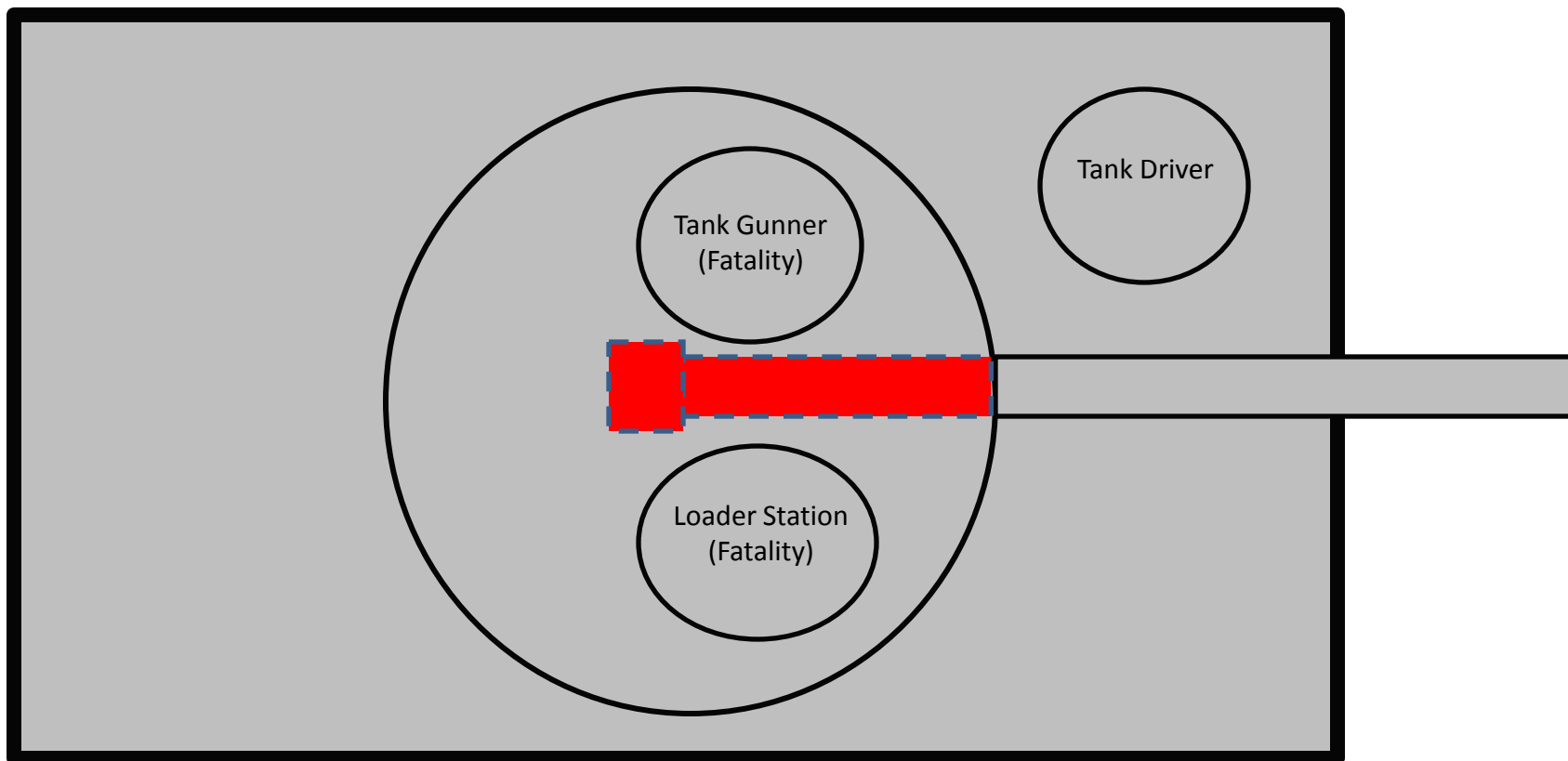
Manned firing of 19 HEAT rounds on H-Field



Accident Timeline

| DATE: | TIME: | EVENT: |
|-----------|------------|---|
| 21 May 09 | ~0700-0800 | Personnel arrived at H-Field and began to setup targets |
| 21 May 09 | ~0815 | Ground support team performed PMCS and bore sighting of the tank |
| 21 May 09 | ~0820 | Test Officer and ground support personnel departed H-Field to draw 14 HEAT rounds from the ammo bunker |
| | ~0845 | Returned to H-Field where the tank was prepositioned; gunner and driver were in position |
| | ~0855 | Test Officer contacted range control on the radio and received clearance to fire |

Crew Positions





Accident Timeline



| DATE: | TIME: | EVENT: |
|-----------|-------|---|
| 21 May 09 | ~0905 | Tank commander positioned at loaders station, communicated with the instrumentation personnel and asked if they were ready to begin testing |
| | ~0918 | Tank commander informed ground crew he was ready for the 1st tank round, from the ammo truck (38 meters away), loaded the round and told the driver to start the tank |
| | ~0921 | Tank moved out and first round fired |



Accident Timeline



DATE:

TIME:

EVENT:

21 May 09

~0923

Ground crew returned to the tank with the 2nd round climbed up the portable stairs , removed the protective cover from the fuze, and handed round to tank commander

~0924

Ground crewman waited to observe tank commander slide the round halfway into the chamber. Ground crewman then exited the rear of the tank noting sound of breech closing



Accident Timeline



| DATE: | TIME: | EVENT: |
|-----------|-------|--|
| 21 May 09 | ~0925 | Tank began to move forward to reach speed of 16-18 KPH |
| | ~0925 | Gunner pulled the trigger |
| | 0925 | HEAT round prematurely detonated in the gun tube |

**Firing
point**



**Tank driver
dismounts**

400 Meters

**Gun Tgt
Line**

T-55

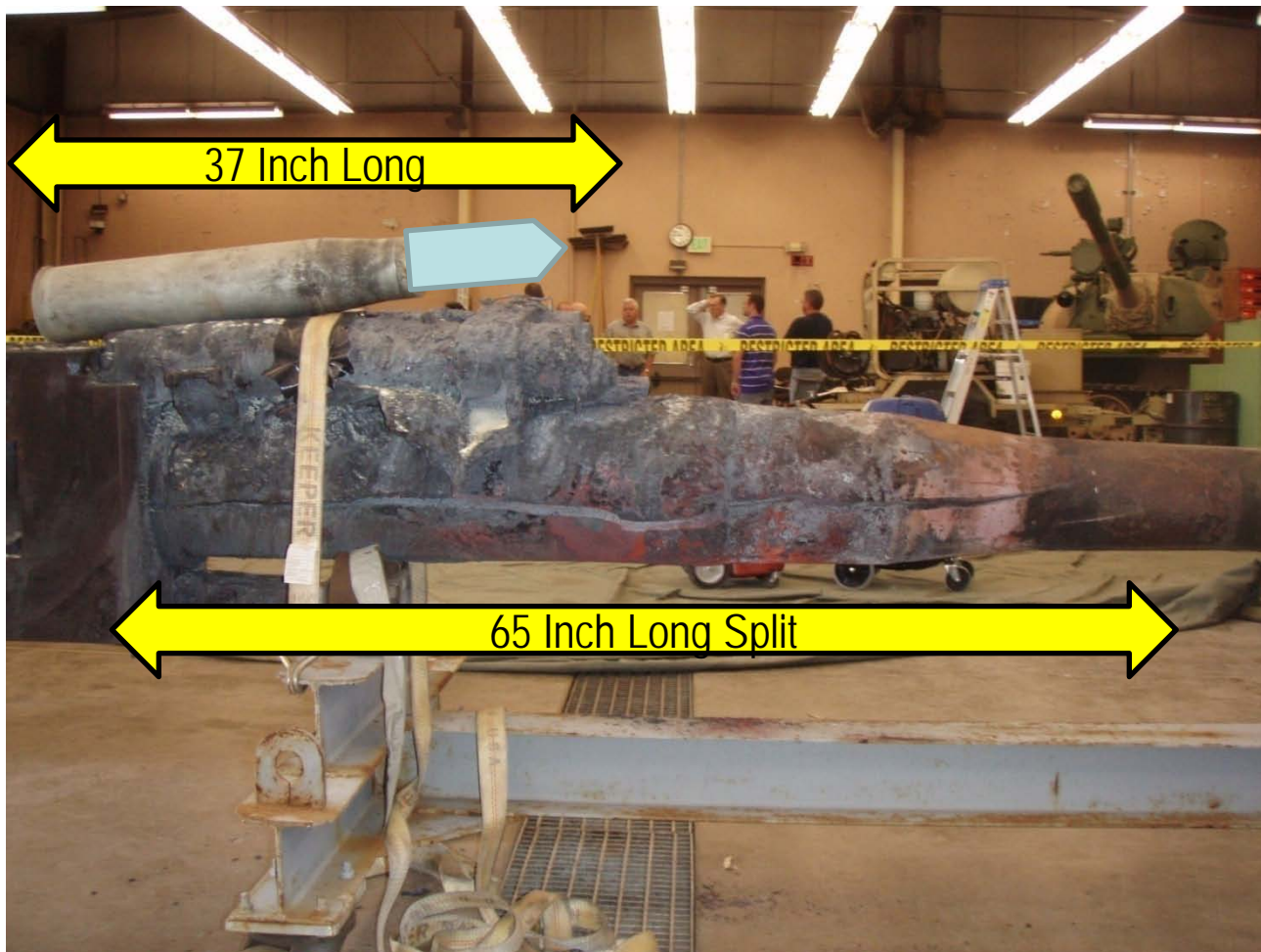
Post Incident

- Environment
 - Sunny, 64°F, winds 4 mph
 - Level gravel range road
 - Tank staged at 2000 m position
 - Target at 3000 m position
- Crew not wearing fire retardant PPE
 - Jeans & t-shirts
 - Steel toe shoes
 - Russian soft tanker helmet
 - SOP ambiguous

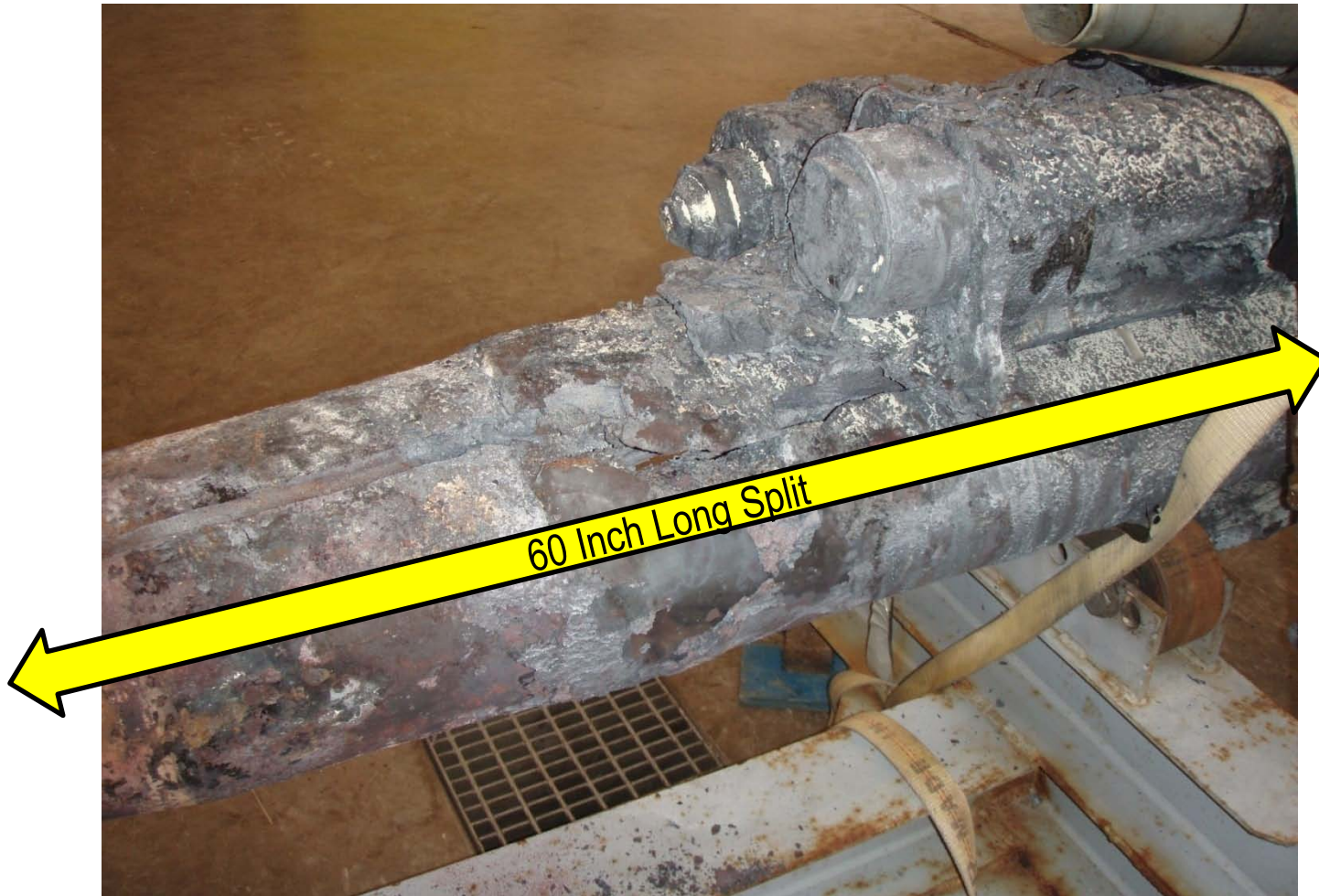
Post Incident

- Gun tube manufactured ~ 1974
- No inspection records prior to 1995
- Benet Labs post incident failure analysis
 - Gun Tube could safely fire HEAT round
 - Projectile detonated in gun tube
 - Projectile traveled ~ 16 inches prior to event
 - Projectile was near maximum acceleration at event

Post Incident



Post Incident



Post Incident

- HEAT rounds not x-rayed in 2009
 - Evidence (0° & 90° marks) of previous x-ray
 - 1999 prior to initial firings.
- Risk Assessment (RA)
 - No documentation found for T-55 firings
 - RA process initiated for T-55 but not completed
 - Documentation on hand addressed firing of different tank system

Post Incident

Medical Response

| | |
|---------|--|
| 0 min | 911 call |
| 4 min | Driver dismounts |
| 8 min | Ground crew arrive at tank and render aid |
| 15 min | EMS arrive and render aid |
| 50 min | MEDEVAC's arrives to transport gunner and driver to medical center |
| ~ 3 hrs | Commander pronounced dead at the scene |

Conclusions

- Incident cause: Premature detonation of HEAT warhead (BK-5M)
- Crew PPE was not adequate
- Risk Assessment
 - Process incomplete
 - Did not adequately address projectile hazards
- EMS response was timely

Recommendations

- Inspect remaining 12 HEAT rounds
- Wide dissemination of incident information
- Suspend manned firing of foreign weapons
 - Case by case review
 - Establish working group of experts
 - Define data required for manned firings
 - Address ammunition, weapon & vehicle
 - Review hazards and potential mitigations

Recommendations

- Establish clear combat vehicle PPE policy
- Review risk assessment process to ensure completion prior to test initiation
- Review EMS test center protocols adequacy